View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by University of Montana

University of Montana

ScholarWorks at University of Montana

Graduate Student Theses, Dissertations, & Professional Papers

Graduate School

2009

MONITORING NOXIOUS WEEDS INVASIONS IN RIPARIAN AREAS FOLLOWING LIVESTOCK EXCLUSION OF THE UPPER BIG HOLE RIVER VALLEY: ADAPTIVE MANAGEMENT UNDER THE CANDIDATE CONSERVATION AGREEMENT WITH ASSURANCES PROJECT

Ana Ingrid Pederson

The University of Montana

Follow this and additional works at: https://scholarworks.umt.edu/etd

Let us know how access to this document benefits you.

Recommended Citation

Pederson, Ana Ingrid, "MONITORING NOXIOUS WEEDS INVASIONS IN RIPARIAN AREAS FOLLOWING LIVESTOCK EXCLUSION OF THE UPPER BIG HOLE RIVER VALLEY: ADAPTIVE MANAGEMENT UNDER THE CANDIDATE CONSERVATION AGREEMENT WITH ASSURANCES PROJECT" (2009). *Graduate Student Theses, Dissertations, & Professional Papers*. 678.
https://scholarworks.umt.edu/etd/678

This Professional Paper is brought to you for free and open access by the Graduate School at ScholarWorks at University of Montana. It has been accepted for inclusion in Graduate Student Theses, Dissertations, & Professional Papers by an authorized administrator of ScholarWorks at University of Montana. For more information, please contact scholarworks@mso.umt.edu.

MONITORING NOXIOUS WEEDS INVASIONS IN RIPARIAN AREAS FOLLOWING LIVESTOCK EXCLUSION OF THE UPPER BIG HOLE RIVER VALLEY: ADAPTIVE MANAGEMENT UNDER THE CANDIDATE CONSERVATION AGREEMENT WITH ASSURANCES PROJECT

By

ANA INGRID PEDERSON

Environmental Science, Montana State University, Bozeman, Montana, 2004

Professional Paper

presented in partial fulfillment of the requirements
for the degree of

Master of Science
in Environmental Studies

The University of Montana
Missoula, MT

June 2009

Approved by:

Perry Brown, Associate Provost for Graduate Education
Graduate School

Len Broberg, Chair
Department of Environmental Studies

Dan Spencer
Department of Environmental Studies

Don Bedunah
Department of Forestry

© COPYRIGHT

by

Ana Ingrid Pederson

2009

All Rights Reserved

Pederson, Ana Ingrid, M.S., Spring 2009 *Environmental Studies*

Monitoring Noxious Weed Invasions in Riparian Areas Following Livestock Exclusion of the Upper Big Hole River Valley: Adaptive Management Under the Candidate Conservation Agreement with Assurances Project

Chairperson: Len Broberg

As a 2008 summer intern working for the Nature Conservancy, I arrived in the Big Hole Valley and was introduced to an innovative federal land management program initiated to benefit government land managers, local ranchers, and the general public while increasing ecological integrity in the valley and recovering the fluvial Arctic grayling species. The government program offered funding assistance to local ranchers for conservation projects that would help recover the species, but the landowner had to agree to a few stipulations; among them are riparian enclosures fenced for 5 years to exclude all domestic grazing.

The goal of this project is to report on the findings of the weeds (specifically Canada thistle) monitoring project established on private riparian lands rested from grazing as a result of the Candidate Conservation Agreement with Assurances (CCAA) program.

Table of Contents

INTRODUCTION

As a 2008 summer intern working for the Nature Conservancy, I arrived in the Big Hole Valley and was introduced to an innovative federal land management program initiated to benefit government land managers, local ranchers, and the general public while increasing ecological integrity in the valley and recovering the fluvial Arctic grayling species. The government program offered funding assistance to local ranchers for conservation projects that would help recover the species, but the landowner had to agree to a few stipulations; among them are riparian enclosures fenced for 5 years to exclude all domestic grazing.

The federal and state agencies are advocates of resting riparian areas from domestic grazing in order to allow willow communities to restore themselves. These willow communities would otherwise be grazed by domestic livestock yearly. Historically, the willows been largely removed by ranchers. They are also attempting to restore normal biophysical parameters of the river. All of these conservation measures will eventually benefit the fluvial Arctic grayling.

Since the project has become well-established among local landowners in the Big Hole, ranchers disagree about how long riparian areas should be rested; they warn of unintended consequences such as invasive weeds infestations in an otherwise mostly weed-free valley. I began a monitoring project regarding noxious weeds in the rested riparian area of the Big Hole River to address this issue. I mainly monitored Canada thistle infestations and general rangeland health on seven privately-owned sites adjacent to the Big Hole River. This paper will detail my methods for the monitoring project, data analysis, and general conclusions about Canada thistle in rested riparian areas, particularly in the upper Big Hole Valley.

PURPOSE

The goal of this project is to report on the findings of the weeds (specifically Canada thistle) monitoring project established on private riparian lands rested from grazing as a result of the Candidate Conservation Agreement with Assurances (CCAA) program.

BACKGROUND

The Big Hole Valley in Southwestern Montana is dominated by traditional lifestyles developed by early homesteaders that are still practiced today. Land-based industries, particularly ranching, are the main source of livelihoods, for the 200 hundred people that live throughout the valley. Also known as "valley of ten thousand haystacks," this valley still uses traditional technologies to stack hay in haystacks and to feed the cattle with horse drawn hay racks. The Big Hole Valley offers premium hay for the rest of the state; while they only get one cut a season, the hay is naturally seeded and has high nutrient value. The Big Hole Valley is one of the highest and widest valleys in Montana. It is an ecologically significant region of Montana; it bears the distinction of being one of the most weed-free valleys in Montana. However, the Big Hole Valley has development and ecological pressures encroaching from all sides. It is the barrier valley against Idaho's invasive species from the West and it battles invasive threats from the Bitterroot Valley to the North, the Beaverhead Valley to the South, and the Silver-Bow area to the East. It has staved off development pressures mostly due to the swarms of mosquitoes during the summer from flood irrigation and brutally cold temperatures in the winter.

COLLABORATIVE WATERSHED LAND MANAGEMENT IN THE WEST

In 1878, John Wesley Powell published his Report on the Lands of the Arid Region of the United States. In his report, Powell addressed the 1862 Homestead Act; suggesting land allotments larger or smaller than a pre-determined160 acres depending on aridity and proximity of the allotment to water. He proposed a radical alternative to the straight-line boundaries and square cornered plots system in Eastern US. Powell recommended irregularly shaped boundaries following topographical features in order to increase access to water for landowners (Kemmis, 2001).

Powell punctuated two main concepts, cooperation and watershed organization. With these ideas, private landowners could organize themselves in terms of an entire watershed. Powell spoke at the Montana Constitutional Convention in Helena of 1889 stating,

> "I think each drainage basin in the arid land must ultimately become the practical unit of organization, and it would be wise if you immediately adopt a county system which would be convenient with drainage basins….I believe that the people who live along every valley in this country should be the people who control three things besides the land on which they live: they should have control of the water, they should have control of the common or pasturage lands, and they should have control of the timber lands" (Kemmis, 2001).

Powell encouraged the state of Montana to act swiftly to amend their local governing of landscapes in order to help start a trend across the West. If Montana would adopt Powell's ideas, then the rest of the Western US would have to follow suit.

Ultimately, Powell's reform was blocked by western politicians with private interest in land resources and conventional patterns of property boundaries. Daniel Kemmis points out that while Powell was ignored at the time, he has certain not been forgotten (Kemmis, 2001).

Since the 1970s a paradigm shift in land management in the West has emerged, hinged off of two key concepts derived from Powell's report: cooperation and watershed organization. Several watershed councils have developed in the last two decades and have proven successful. These organizations bring diverse stakeholders together, who have worked together effectively for a few years, but have repeatedly been frustrated by the federal land management system (Kemmis, 2001). As law professor, David Getches states, "The key is going back to Powell's wisdom that this river and this watershed can be the unifying device, socially and culturally, for the west."

The Big Hole Watershed Committee (BHWC) was formed in 1995 by ranchers and conservationists concerned about water use and distribution, changing land management programs and practices, and developing restoration projects. The Committee is comprised of 22 governing members, including ranchers, government employees, outfitters, and conservationists that live from Melrose to Jackson. The committee addresses myriad land management issues and makes decisions by consensus.

The BHWC is crucial to organizing collaboration throughout the watershed. It offers funding assistance for land restoration projects under the Candidate Conservation

Agreement with Assurances (CCAA program). Among its largest achievements is the creation of a basin-wide drought management plan. Most importantly, the Committee also helps coordinate key players in collaborative land management and initiates conversations between diverse stakeholder perspectives at their meetings

STATUTORY REGULATION UNDER THE ENDANGERED SPECIES ACT (ESA)

The purpose of the Endangered Species Act is to *"provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved".* (16-35-1531) In effect, the ESA outlaws extinction of a listed species; furthermore, its intent is to recover the threatened population in question. The ESA serves as an "emergency room" for critically threatened species, and often it is the last resort for saving the species before extinction (Nie, 2008). The ESA seeks to recover populations from a significant portion of its "historical range." The historical range for the fluvial Arctic grayling is two watersheds in the lower 48, thus defining the Upper Big Hole as a "significant portion."

At the center of this well-intentioned act is conflict and debate regarding taking of species' critical habitat under the Endangered Species Act and interference with landowner private property rights. Section 9 of the ESA prohibits the "taking" of endangered species. A "taking" is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (16 U.S.C. § 1531 (7)). It is this section that delegates regulatory power to agencies on privately-owned lands.

As a result of prior conflicts of Section 9 with private property interests (such as the spotted owl), many landowners have learned that it may be in their best interest to actively manage their land to avoid harboring critical habitat for the candidate species. Thus, if the species becomes listed and is not found on or adjacent to their property, they will not have to worry about any “takings” violation under the ESA.

The Department of Interior recognizes evading “takings” under the ESA may be more detrimental than allowing some landowner certainty and agency flexibility in application of the statute. Thus, the DOI has created programs that offer landowners and land managers incentives to help conserve and restore critical habitat for a candidate species without being liable for any “takings.”

As a means to mitigate the takings controversy associated with several land uses, alternative tools such as Candidate Conservation Agreement with Assurances (CCAAs) are being implemented by US Fish and Wildlife Service. CCAAs provide regulatory assurances to non-Federal property owners who voluntarily agree to manage their lands or waters in such a way that threats to candidate species, proposed species, or sensitive species may become significantly reduced (USFWS, 2008). CCAAs are used to encourage non-Federal landowners to voluntarily implement proactive conservation measures that benefit grayling ”...by providing [the landowners] with assurances that their land and management activities will not be required to change beyond the remedies identified in their site-specific plan should grayling become listed as threatened or endangered" (RLCH, 2008). It is important to note that only *listed* species mandate the protection of the ESA; the intention of the CCAA is to foster an interest in private landowners in conservation of the species before the candidate species is listed and the protection is mandated.

CCAAs are specifically directed to support conservation on private lands since much of the land harboring our nation's biodiversity lies within private jurisdiction. CCAAs are entirely voluntary and collaborative. The program is facilitated by the US Fish and Wildlife Service (US FWS) in conjunction with local agencies and the landowner. The federal agencies will help fund restoration projects on the private land to help minimize negative impacts on the candidate species, while also assuring protection of the landowner's uses against "takings." This program also creates a more collaborative approach to larger working landscapes by connecting federal and private lands.

The Service must ensure that the benefits of conservation measures implemented by the property owner under a CCAA would preclude or remove any need to list the covered species (USFWS, 2008). Each CCAA is tailored to every individual landowner and includes several partnerships between NRCS, DNRC, FWS, FWP, and sometimes NGOs. Oftentimes, there are positive unintended consequences for other species that share similar habitat as the candidate species.

The first CCAA program was implemented in 2000 by the Oregon Department of Fish and Wildlife for the sharp-tailed grouse (RLCH, 2008). Today, the largest CCAA project is located in the Big Hole Valley, MT protecting the fluvial Arctic grayling *(Thymallus arcticus)*. This valley is home to the only river in the lower 48 that still supports a fluvial Arctic grayling population. However, it is critical to point out that historically, only two watersheds harbored fluvial grayling in the lower 48 states (CBD, 08); the upper headwaters of the Missouri in Montana and one other watershed in Michigan. The Michigan population is now extinct. The survival of the Arctic grayling in the Upper Big Hole is contingent on water quality and quantity. Thus, any effective CCAA must conserve and restore those habitat elements while accommodating continued agriculture in the watershed.

The fluvial Arctic grayling has been proposed as a "candidate" for ESA listing for more than two decades. In 1982 the fluvial Arctic grayling was designated a Category 2 (nonsufficient data to justify ESA listing) species due to survival threats. In 1991 the species was petitioned for listing under the ESA; the grayling was declared "warranted, but precluded" in 1994. In 2004, the grayling designation was decreased to Category 3 (a species once listed as Category 2 and after subsequent data, ESA listing is not appropriate). At this time, the Center for Biological Diversity filed a lawsuit to force the Service into action. While the population numbers were low, the Service decided on April 24, 2007 that the grayling's candidacy was not warranted for the species. The Center for Biological Diversity and Western Watershed Project are currently involved in litigation in an attempt to force the Service to reconsider their decision (CBD, 2008).

RANCHING LIVELIHOODS VERSUS FLUVIAL ARCTIC GRAYLING HABITAT

Fish biologists have difficulty observing the fluvial Arctic grayling during spawning due to runoff and turbid waters; however, they all agree that cold water fishery habitat is essential for the grayling's survival. The fluvial Arctic grayling requires cold water temperatures, shaded undercuts, a healthy functioning river with appropriate riffle to pool ratios and plenty of diverse river morphology for each of its different life stages. Land managers are targeting the most immediate human-influenced threats to the grayling in the Big Hole River which are "habitat loss, degradation and fragmentation resulting from (1) reduced stream flows; (2) degraded and non-functioning riparian habitats; (3) barriers to grayling movement; and (4) the potential for grayling entrainment in irrigation ditches" (RLCH, 2008).

In order to produce hay, the Big Hole Valley has an extensive network of irrigation canals leading from the Beaverhead Mountain snowpack, winding through hay meadows, and surface irrigating the entire valley. While the canals in the fields and adjacent to the roads provide great habitat for avian wildlife, the water that eventually makes it to the Big Hole River is only a fraction of what left the mountain snowpack. Traditional ranching techniques consume a large quantity of water; thus lack of water and unusually warm temperatures are the main obstruction to healthy habitat for the fluvial Arctic grayling. The BHWC has been working on a collaborative front with ranchers and landowners to mitigate water use with their drought management plan which secures critical in-stream flows.

The agencies see the riparian-grazed rest period as a great way to simultaneously increase stream bank stability while also rehabilitating a healthy plant community for increased water storage in the riparian areas, thus holding water for longer flow periods of the year. Together, these processes may alleviate high temperature and lack of water throughout the summer months in the Big Hole River.

Historically, many ranchers (not all) removed thick willow stands in riparian areas. Their reasoning was practical; thick willow stands made moving cattle difficult.

As a result, the willows were dug up, bulldozed, piled high, and burned. The government agencies are launching a valley-wide restoration project to bring willows back to the Big Hole riparian system. Agencies collect clippings from the valley, propagate them at the DNRC state nursery in Missoula, MT and then plant the willow plugs the next spring. Contracted restoration companies are also transplanting mature willows on high-risk stream banks.

THE ROLE OF CANDIDATE CONSERVATION AGREEMENTS

In 2003 Candidate Conservation Agreements with Assurances were introduced to the Upper Big Hole Valley. The specific components that this CCAA focus on include: riparian restoration, bank stabilization, water conservation, and fish passage through the watershed. There are 32 enrolled landowners. These areas under the CCAA include 6,030 state-owned acres, 152,139 privately-owned acres for a combined total of 158,169 acres (Lamothe, Rens, Everett, Magee, and Roberts, 2008). Collaborating partners include the USFWS, MT FWP, DNRC, NRCS, The Big Hole Watershed Committee, The Nature Conservancy, and The Big Hole River Foundation. These partners have helped fund stock water systems, on-site wells, fish ladders and fish screens, bank stabilization projects, and have assisted landowners with new grazing management plans. These projects will improve conditions for 156 riparian species (Lamothe, Rens, Everett, Magee, and Roberts, 2008).

Most impressive are the 64 miles of riparian area that have been fenced with removable tiers. To date, 37 off-stream stock well water systems have been implemented to mitigate low in-stream flows. In order to assist fish passage, 9 fish ladders have been installed along the river. Also, irrigation infrastructure and fish screen have been placed at all head gates. Other restoration projects include 6 confined-animal feeding operation clean-ups (Lamothe et al., 2008).

OWNER/AGENCY CONFLICT IN THE BIG HOLE VALLEY

In the Upper Big Hole a landowner that has signed the agreement is required to rest their riparian areas for five years. The agency funds the fencing (chosen by the landowner) for the riparian rest zones in hopes of rejuvenating native plant communities that will help stabilize stream banks and create shaded streamside habitat. However, landowners are concerned about the adverse impacts that a five year rest period will have on the un-grazed riparian areas. Landowners have speculated that these areas allow grasses to grow tall, reach their productivity climax, fall over, become decadent with increasing depth of litter, increasing bare soil and inviting noxious weed invasions.

As a result, collaborative groups have called for the implementation of a weed monitoring program that will help mitigate possible unintended consequences.

ADAPTIVE MANAGEMENT MONITORING

Adaptive management is a crucial tool in dynamic ecosystems where little is known about the determining variables that make the ecosystem function. Given the myriad variables, natural system function often eludes human prediction. Long term fluctuations within a system can be based on scales of centuries; hence our recent evaluations may not be sufficient to predict future patterns. The effects of climate change compound other variables contributing to the ecosystem. For instance, water supply is greatly affected by climate driven long term drought.

Adaptive management creates a continuous loop for planning, implementing, evaluating, and modifying. The main steps used to create adaptive management schemes within government projects are 1) assess the status of a population and its habitat, 2) plan and implement a program to protect the population and its habitat, 3) monitor results of the program and assessing which goals were met, and 4) alter plan and program, if necessary, to meet objectives (U.S. Department of Interior, 2008).

The projects initiated in the valley should contribute to the effort for enhanced habitat for the fluvial Arctic grayling; however, neither the agencies nor the landowners are certain of the effectiveness of the conservation project. As a result, several monitoring projects have been developed in order to evaluate sediment transport in recently reclaimed stream stretches, grazing effects from wild and domestic ungulates, bird populations as an indicator species, and weed populations. The adaptive management monitoring component of these projects reduces conflict between landowners and agencies, maintaining flexibility within a restoration project.

The CCAA project has been very successful in getting diverse players to the table. While outstanding working relationships exist, possible sources of contention must be addressed swiftly. Among those tensions are riparian fences that have been built for five years in order to restore riparian areas; landowners speculate that there are unintended consequences on the land. The landowners vocalized concerns to the agencies, particularly MT FWP, about increased weed communities in these areas as a result of grazing absence.

As a result, MT FWP has contracted Ray Tillman, Pintler Weed Management, to mitigate the most problematic infestations while the weed monitoring project is executed in the rested riparian areas. Ray Tillman is contributing baseline data on how grazing versus non-grazing affects weed communities in riparian rest zones and on the effectiveness of herbicide treatments.

The monitoring projects are meant to be long term and provide data for how the last five years of the CCAA program have affected habitat for the fluvial Arctic grayling. The addition of new CCAA landowners has been staggered and thus many of the monitoring projects observe different periods of CCAA integration on private lands.

During my monitoring in the Big Hole I was not working for any one specific side, nor was I prescribing management regimes to private lands. I was an independent student with independent funding making my own relationships in the valley with landowners and government officials alike. I was monitoring to answer the question of whether a five year rest period helps increase noxious weed infestations. Based on the outcome of the data, appropriate alternatives will be proposed to address the findings of this monitoring program.

LITERATURE REVIEW

Riparian Areas

Knopf and Samson (1994) note, ‘‘Although less than 1% of the western landscape of the United States supports riparian vegetation, this vegetation provides habitat for more species of breeding birds than any other vegetation association in western states.’’

Native riparian vegetation serves myriad purposes for a healthy functioning system. These vegetative systems serve as a water purifier by separating out sediments and pollutants. Riparian vegetation is integral in not only cleaning the water, but also reinforcing stream banks.

Riparian systems slow the flow of water and allow it to spread and soak into the banks like a sponge (U.S. Department of Agriculture, 1989).

The diversity of grasses, forbs, sedges, rushes, shrubs and trees produces a variety of fibrous and tap roots that bind and hold settled soils in place. Weeds are not as stabilizing as native riparian vegetation against water's eroding energy (U.S. Department of Agriculture, 1989).When a noxious weed such as Canada thistle is introduced to an ecosystem, the native vegetation is quickly displaced; competing for nutrients, water, and sunlight. Reduced species diversity resulting in a near-monoculture can be the greatest threat of Canada thistle (Van Woudenberg, 1999).

Ringold, Magee, and Peck (2008) monitored perennial streams and rivers in 12 western states for invasive species coverage. Twelve invasive species were classified as a threat including: Canada thistle, cheatgrass, common burdock, english ivy, giant reed, himalayan blackberry, leafy spurge, musk thistle, reed canarygrass, russian olive, saltcedar, and teasel. Species were chosen for monitoring based on ecologically varied cultivation, ease of identification, truly invasive action, ecologically or economically intrusive effects, nontoxicity on touch, riparian presence and a regional (rather than local) distribution (Ringold, Magee, and Peck, 2008). Montana had more stream length sampled than any other state; Canada thistle was the overall largest threat to Montana riparian zones and those in the combined 12 western states.

Canada thistle

Canada thistle (*Cirsium arvense (L.) Scop; CT)* is a perennial noxious weed in the Asteraceae family. CT is widely distributed; while it is prone to growing in highly disturbed sites, it is also a predominant invader in cropland, rangeland, and riparian areas.

Canada thistle is speculated to create greater crop losses than any other perennial broadleaf weed throughout the northern half of the United States and all of Canada (Wilson and Kachman, 1999).

Canada thistle has a complicated growth pattern; plants are distributed by seeds, roots and rhizomes. CT rosettes emerge in early May. After a two-leaf stage, the weed extends laterally-creeping vegetative structures to colonize adjacent areas. Vertical shoots extend in late June and flowering occurs in July and August. Their seeds, if buried deep, can persist for 20 years (Sullivan, 2004).

The vegetative structures are crucial for the rapid colonization of an area (Hanson, 2009). Even a half-inch piece of Canada thistle can grow into a new plant (Anderson, 2001). These rooting systems can survive for several years in soil staying unaffected by occasional mowing or livestock grazing. The underground vegetative structures can extend three feet or more down and15 feet or more horizontally throughout the soil profile. These massive root systems serve as a large reserve for carbohydrates; the reserve increases the plant’s survival through freezing, tillage, mowing, and chemical treatment. Because of rhizomatous spreading, young colonies are often genetically identical (Hanson, 2009). Weed ecologists suspect Canada thistle may contain allelopathic compounds which poison adjacent species; however this concept is controversial and is difficult to support with data (Stachon and Zimdahl, 1980).

The objective of this monitoring project is to determine if grazing does help manage Canada thistle infestations in the riparian areas of the Big Hole Valley and if the absence of grazing is aiding new CT proliferation. Perhaps landowners are cautious to graze early in the spring with peak runoff and super-saturated soils. This summer, one landowner informed me that typically cattle will graze CT after the plant has flowered. However, the grazing occurs after the plant has flowered and sent carbohydrate reserves to the root system spreading infestations.

When grazed young, Canada thistle contains a higher concentration of Nitrogen and moisture. They also have adequate crude protein for cattle and lower lignin levels (Canada, 2005). Rosettes demonstrate greatest palatability, with the highest concentration of N and greatest amount of moisture throughout the life cycle of CT. Grazing during rosette stage is also more effective than in more mature stages because CT has an elevated meristem. Repeated damage to the meristem halted shoot development and forces the weed to regrow from root buds, a process that can result in prolific new shoot production (Amor and Harris 1977).

Grazing Management for Canada thistle Control

The effectiveness of using grazing as a weed control tool for CT is controversial. Grazing CT can inhibit seed production and also control root establishment (Donald, 1990). In order to most effectively control Canada thistle through grazing management, it is best to begin grazing this perennial in the spring as a rosette. Once the desirables emerge remove grazing; return grazing with the re-growth or flowering of CT (DeBruijn, 2006). This treatment may need to be repeated every three years. The treatment is most effective when done several times throughout the season and repeated each season in order to deplete root reserves (Donald, 1990).

While goats, sheep, and cattle are all effective grazers, goats will graze old CT plants and are overall most effective. Optimal results are achieved when two controls are applied jointly, such as grazing and herbicide application.

The Alberta Agricultural Research Institute has studied grazing regimes that may help minimize Canada thistle infestations on pasture lands. The AARI applied three different grazing regimes: continuous, high intensity-low frequency (HILF), and short duration (SD). Short Duration is defined as moderate defoliation at frequent intervals during August or highest levels of biomass.

HILF was the most effective grazing system for Canada thistle reduction. HILF occurs more than once a year and employs higher stocking coverage in less frequent grazing periods. HILF has high animals per unit area which encourages CT stems to be trampled, broken, stripped which may allows for easier disease entry. Also, the high intensity nature of HILF grazing promotes livestock to incidentally graze CT adjacent to desirable forage. HILF is particularly effective against CT in the last two days after the desirable forage is either grazed or trampled. CT plants have stronger average stem strength, making CT most accessible in the last two days of the grazing period (Canada, 2005).

To maximize HILF grazing reduction of CT, grazing should occur before the bolting stage. Repeated disruption to CT development before bolting stage depletes root carbohydrates, similar to repeated mowing or tillage (Donald 1990). This process limits flowering capabilities and therefore seed production. Besides reduced numbers of CT, HILF results in higher pasture utilization and greater forage production (Canada, 2005).

Short duration was the second most effective defoliation treatment, this method employed clipping at maximum biomass in August which may be more applicable to riparian areas. SD allows grasses to stay competitive because of conservative defoliation (leaving more biomass for regrowth) (Canada, 2005). This, however, was not enough of an advantage to achieve anything more than a partial reduction in CT. Compared to the HILF treatment, it appears the SD treatment may not be as advantageous to enhancing grass growth as previously thought with little impact on associated weeds (Belsky 1986). However, any defoliation method coupled with another weed control regime has largely successful results.

One year after grazing treatments ended, there was no difference in CT coverage between the continuous and SD treatments, indicating the SD system did not alter CT populations. The effects from HILF grazing systems endured after the discontinuation of HILF, even after a continuous grazing system was once again re-established (Canada, 2004).

This study acknowledges that some producers are wary of an HILF system; hence, the study recommends utilizing HILF as a prescriptive treatment until CT populations have been reduced, with a SD system then used to maintain low CT populations. Continuous grazing systems promote selective grazing by livestock with allows CT to reach advance stages of growth, where palatability and nutrients are lower (Canada, 2005).

While HILF grazing has been recognized as an effective weed control option for Canada thistle, the HILF technique is not appropriate for sensitive riparian areas. HILF grazing could cause more damage to the riparian area than new Canada thistle infestations and it is not applicable in the Big Hole CCAA riparian zone due to the need to maintain low water temperature, high water storage and high water quality.

Absence of Grazing in Riparian Areas

There is very little literature available that observes the absence of grazing in pasture land. It is difficult to quantify those changes and evaluate their relationship to a weed community. However, literature suggests that young seedlings have great difficulty emerging from below a thick cover of grass or dense mat of dead grass on the ground (Sullivan, 2004).

Canada thistle has been observed to grow in areas where soil calcium levels are low, iron is high, and phosphorus is low or complexed. Thistles prefer soils high in anaerobic bacteria where residue decay is poor, or the soil is compacted (Anderson, 2001). Both anaerobic soil conditions and high concentration of iron exist in the Big Hole Valley riparian areas.

Most studies comparing grazed and protected riparian areas show that some plant and animal species decrease in abundance or productivity in grazed sites while other species increase. Plant species that commonly decline with livestock grazing are either damaged by removal of their photosynthetic and reproductive organs, or are unable to tolerate trampling or the drier conditions caused by lowered water tables. Plant species that commonly increase with livestock grazing are usually weedy exotics that benefit from disturbed conditions or sub-dominant species that are released from competition when taller neighbors are grazed down (Kauffman and Krueger and Varra, 1984).

Over-resting in Riparian Areas

Many grazing regimes have been recommended by several range scientists. Among those grazing regimes is the Allan Savory Holistic Resource Management (Savory,2006). Savory's ideas evolved in Africa and he has since brought them to the North American West. He has declared that US Western lands are in the terrible condition (Russsell, 2001). His background as a wildlife biologist has helped him adapt domestic cattle to rangelands in replacement of large wildlife ungulates that once roamed the Western Range such as bison, elk, and deer.

Savory argues that overgrazing in quick, intensive periods mimics natural grazing regimes more naturally. Several processes are important to these intensive grazing prescriptions. First, the hoof action helps break up brittle biomass in arid landscapes that would otherwise take a much longer time to cycle its nutrients back into the soil. This also helps clear out decaying plant biomass so that new re-growth can photosynthesize efficiently. The other process that occurs from the intensive hoof action is the constant disruption of soil crust formation that would preclude infiltration of precipitation into the soil profile.

The main caution is not to overgraze. Once animals have intensively grazed an area, it is crucial to move them before they return to the plant for a second bite and cause long lasting damage to the grasses.

Savory classifies the West's arid climate as "brittle" for grasslands; he even suggests that brittle environments such as these *need* cows. Savory acknowledges that riparian zones are crucial for silt collection, bank stabilization, and water storage but offers a historical perspective; pointing out that wildlife (elk and bison) used these watering holes frequently and played an important role with their hoof action. The trick is to help cows mimic the same patterns demonstrated by wildlife (Savory, 2006).

The controversial debate is whether domestic cattle can really mimic wildlife, particularly in riparian areas. Many scientists and textbooks are hesitant to subscribe to such ideas, as well as agencies working in the Upper Big Hole. Still, many ranchers declare that rotational grazing or a rest period of three years are better alternatives to healthy riparian ecosystems than a five year rest period.

Effects of Litter Depth

The presence of litter alters the micro-environmental conditions of the top soil. Litter intercepts incident light and rain, and changes the surface structure, affecting the transfer of heat and water (and probably gasses) between the soil and the atmosphere. These parameters affect plant community structure directly (through their effect on germination and establishment of plants) or indirectly (through changes in the resource availability and through the effect on other biotic components) (Facelli and Pickett, 1991).

Litter effects on seeds and seedlings may be physical, biological or chemical (Facelli & Picket, 1991). Litter may increase seed longevity by reducing soil temperature (Chambers & MacMahon, 1994) or increase seedling establishment by improving water availability (Evans& Young, 1970; Carson & Peterson, 1990), but may reduce seedling germination by directly reducing soil–seed contact (Chambers, 2000; Fowler, 1986). Other litter effects include the promotion of seed pathogens (Chambers & MacMahon, 1994) and the release of nutrient and/or toxic substances (De Jong & Klinkhamer, 1985). Further, the effects of litter on seedling emergence can depend on the particular species and on the grazing treatment suggesting that litter can produce a range of combinations of positive and negative effects on the various processes involved in plant regeneration.

The effects of litter on different environmental variables and the different responses of various populations to its presence preclude a general prediction of the effect of accumulated litter on community structure. Many of the studies conducted are good examples of how different effects of litter may interact to yield different results in different systems. (Facelli and Pickett, 1991).

Experiments were performed to study the effects of litter on seed longevity in the field as well as greenhouse. Results in the greenhouse concluded that litter increased seed longevity and also increased seedling emergence and growth for surface, but not for buried, seeds. (Rotundo and Aguiar, 2005). In the field, litter did not increase seedling emergence or survival in the field. More often, the positive effects of litter on seed germination were greater than the litter acting as a mechanical barrier. (Rotundo and Aquiar, 2005).

There are few conclusions about the mechanics of litter depth and seedling emergence; however we know that reduced grazing intensity increases plant litter depth. Litter may prevent the germination of plants that respond positively to light (Grime, 1979). Seedling establishment may also be negatively affected through light deprivation by litter. Hamrick and Lee (1987) found higher mortality of seedlings that germinated under a thick layer of litter.

In grasslands with dense litter depth, plants grow more slowly and flower more sparsely due to lower soil temperatures during spring (Rice & Parenti, 1978). However, Knapp and Seastedt (1986) reported that both soil and air temperature within the canopy were higher in undisturbed grasslands stands, because litter reduced convective cooling. They attributed low productivity of ungrazed prairies to warmer soil temperatures in spring, which worsen water conditions.

` The presence of litter affects the exchange of water between the soil and the atmosphere. This effect has been amply observed in grasslands and deserts (Fowler, 1986) where litter increases water availability. Litter depth in ungrazed grasslands increases infiltration and reduces evaporation from the soil (Fowler, 1986). Hamrick and Lee (1987) found that seeds of musk thistle (*Carduus nutans*) were retained by a thick layer of litter which prevented them from reaching the soil.

Seedlings and sprouts emerging from beneath a litter mat have to devote energy and time to penetrate it. Seedlings produced by small seeds may be unable to emerge, because of energy shortage (Knapp & Seastedt, 1986). The Canada thistle seedlings are weak competitors if they are shaded by the crop (Hanson, 2009). Seedling geometry may be an important determinant of the ability of a seedling to penetrate the litter mat. The position and size of the cotyledons during emergence may affect the resistance of the litter to the growth of the seedling. Though sprouts usually have more energy available, there is some evidence that thick layers of litter can impair their performance (Knapp & Seastedt, 1986).

Fowler (1986) found that litter reduced competition and increased growth rates because of reduced plant coverage. Litter depth may reduce species richness in grasslands (Facelli, 1988). Litter removal usually increases species diversity and the number of flowering species in grasslands (Penfound, 1964).

OBJECTIVES OF RIPARIAN VEGETATION MONITORING

With the first year's data, the goal of the adaptive monitoring project is to answer two different research questions:

- Are there significant differences in the amount of litter and bare soil at sites with longer rest periods?

- Do plots with five years of rest have significantly higher coverage of weed infestations than the plots with three years or less of rest?

With subsequent years of monitoring, we can observe the relationships between grazing absence of grazing on vegetation composition, volume of litter present, percent ground cover, and invasive weed populations from year to year at each site. I will also observe the effectiveness of herbicide applications as a means to mitigate a five year riparian rest period and increased weed infestations. The purpose of research in subsequent years will be to answer the following questions:

- Is the herbicide application a viable solution during the five year livestock grazing?

- How have the relationships between the three variables of weeds, bare soil, and litter depth changed within the same site from year to year?

- Are there any new species of invasive weed infestations other than previously observed?

SITE SELECTION

I chose sites that demonstrated different stages of the five year rest period, but similar habitat characteristics and geographical location, and landowner cooperation. A random stratified approach to was used to choose transect locations. I only sampled transects in the riparian zones. The riparian areas were delineated by soils and vegetation. At times, the width of riparian areas only allowed room for two plot placements. I also placed more transects in areas that represented denser weed infestations. At sites that had none to minimal weed infestations, three transects with three plots on each transect was the minimum. Minimum weed coverage were characterized by the necessity to actively search for infestations in the riparian areas.

I have seven properties total, and six of them demonstrate vegetative community responses as a function of a policy-mandated rest period. The Husted property is not enrolled in the CCAA, rather it serves as a reference reach for healthy riparian ecosystem and will not be fenced. The thick vegetation at this site act as a natural barrier for riparian area cattle grazing. Each site demonstrates different stages of rest from grazing; for instance, Husted and Swamp Creek have not been rested (the Swamp Creek fence has not been completed-the fence is slated for completion in April 2009) while Steel Creek just exited its five year rest period. Hirschy and Erb properties represent interim rest periods and Jackson and Lapam represent fenced with no rest sites.

METHODS FOR RIPARIAN VEGETATIVE MONITORING

I chose a minimum of three 30-meter transects within each of the seven sites. All transects were perpendicular to the river and extended as long as possible without exiting the riparian area or reaching upland slopes, molisols, and yarrow/ sage plant communities. I located at least two Daubenmire plots (one square meter) along each transect with the first plot placed within the first 3 meters determined by a random number generator. All following plots were placed systematically at 3 meter intervals. Seven different properties (some adjacent to each other) that contain a total of 52 transects and 181 total sampled plots made up the entire sample. In each plot, I measured (or estimated) litter depth within the plot, percent coverage of each category: ground cover, noxious weeds, litter, non-invasive vegetation, water, cattle fecal matter and woody debris.

Refer to Appendix A, a summation of the different sites and how long they have been rested is provided and Appendix C is a GIS site map. Included in Appendix A are the number of transects within each property and number of plots on each transect. The sites that were sampled to also answer questions regarding herbicide effectiveness are Steel Creek, McDowell Stretch, and Little Lake Creek. The sites used for monitoring invasive weed communities during the un-grazed rest period are (Steel Cr-Hirschy, McDowell Stretch-Erb, and Swamp Creek-Erb) Some of the properties are involved in both parts of the monitoring scheme (grazing and herbicidal effects on weed communities).

Table 1. Weed Monitoring Site Descriptions

2008 Sampling	Steel Cr.	McDowell St.	Little Lake	Swamp Cr.	Jackson	Lapam	Husted*
Acreage	79	1045	168	280	70	70	70
Transects	13	10	13	13	5	3	3
Plots w/in Transects	57	45	19	57	19	8	12
Years Rested	5	2	1	0	0	0	0

* landowner not enrolled in CCAA

The FWP contracted Ray Tillman to apply herbicidal weed control at the end of 2008 on three sites (Little Lake Cr., Steel Cr., and McDowell Stretch). My 2008 sampling season recorded weed coverage prior to the herbicide application; sampling season 2009 will monitor the effectiveness of the first herbicide application. I also have a final report from Ray Tillman detailing his spraying methods and observed problematic spots within each property site.

DATA ANALYSIS

In order to discern trends in the riparian rest areas, I will need subsequent years' data. After only the first year I examined these questions:

i. Is litter increased with increased rest periods?

ii. Is bare soil increased by longer rest periods?

iii. Is there a significant increase in weed coverage between 2 years rest and 5 years rest properties?

This monitoring project will also help establish invasive weed baseline data for Big Hole land managers. It will also help identify any current or potential problem infestation areas.

I compared weighted mean litter depth, weed coverage, and bare soil percentage for each property according to how many Daubenmire plots are located within that property. For example, the McDowell Stretch has more transects than Lapam or Jackson properties.

SUMMARY OF FINDINGS

Table 2 summarizes measurements of each variable (weed coverage, vegetative coverage, bare soil, and litter depth) for the seven sites monitored in field season 2008.

This table shows means weighted by the number of transects monitored at each property. There are no detectable differences in weed coverage between rested and grazed sites, regardless of the length of rest (Figure 1 and 2, Table 2). Nor were there any detectable differences in litter depth based on length of rest (Table 2, Figure 3), although the two longest rested sites did show the highest mean values in the sample.

Table 2. Monitoring Data Summary; 2008. Weighted means of measured site characteristics STE is a single standard error

Property	# Plots	Years Rested	Vege-tation	(STE)	Bare Soil	(STE)	Weeds	(STE)	Litter Depth	(STE)
Little Lake Cr.	19	1	60.2	13.8	8.9	2.0	18.0	4.1	0.9	0.2
Husted	12	0	56.3	3.0	9.3	2.3	10.3	1.9	2.1	0.6
Jackson	18	0	52.5	3.3	11.1	3.3	8.8	2.1	3.0	0.8
Lapam	8	0	68.1	5.7	14.8	1.4	0.8	0.8	2.0	1.8
McDowell St.	27	2	6.4	2.6	9.0	1.8	8.3	1.9	3.8	1.2
Steel Cr.	58	5	56.7	1.7	9.0	1.1	10.5	1.1	3.1	0.3
Swamp Cr.	46	0	80.6	1.6	7.0	1.4	0.1	0.1	1.2	0.2

[1]

[1] Table 2 does not include % coverage of non-categorical items such as rocks, livestock fecal matter, water, or woody debris.

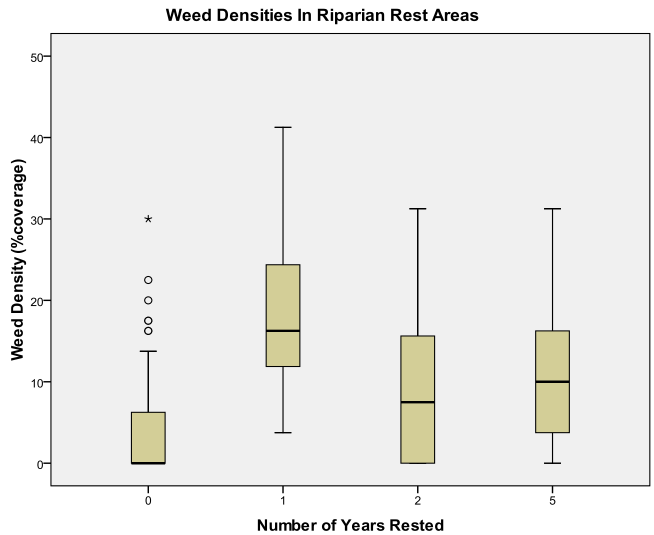

Figure 1. Weed Coverage in Riparian Rest Areas. Error bars represent one standard error, open circles outliers and stars represent extreme outliers. Coverage calculated by transect mean in each category.

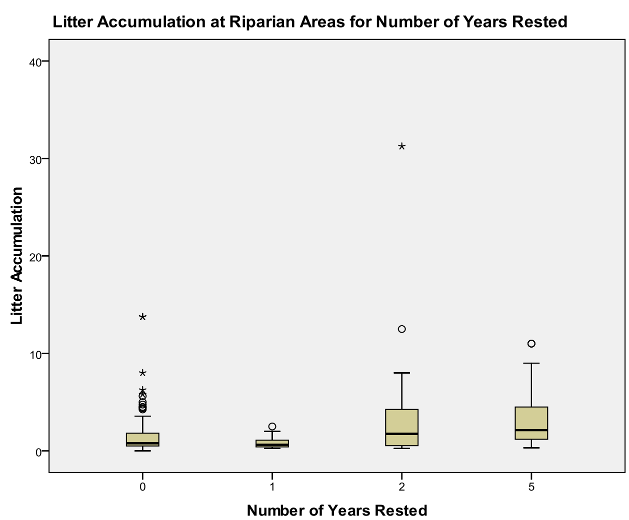

Figure 2. Litter Depth (cm) in Riparian Areas for Number of Years Rested. Error bars represent one standard error, open circles outliers and stars extreme outliers. Calculated based on transect mean in each category of rest.

It is difficult to distinguish any patterns after only one year of data collection. Although discerning answers between relationships defined by length of grazing rest and noxious weed coverage is not possible from this data, there are two relationships that are consistent with prior range ecology studies. First, more native vegetation is associated with lower invasive weed coverage (Corbin and D'Antonio, 2004). Second, the effects of litter on different environmental variables and the different responses of various populations to its presence preclude a general prediction of the effect of accumulated litter on community structure. (Facelli and Pickett, 1991).

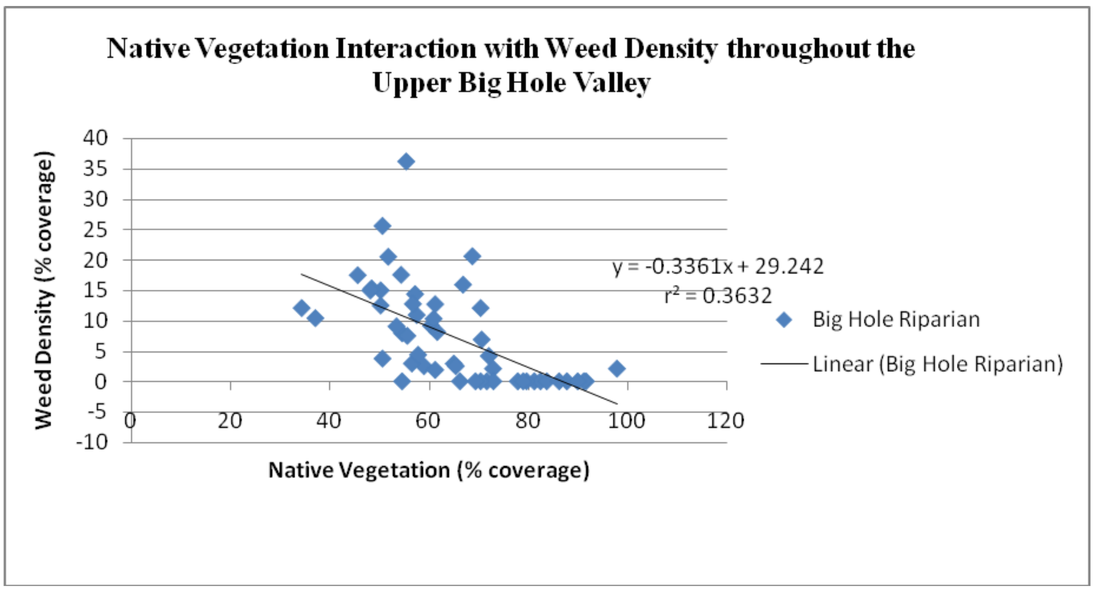

Figure 3. Native Vegetation Interaction with Weed Coverage throughout the Upper Big Hole Valley.

Vegetative coverage and weed infestations also show the same negative correlation if analyzed within a transect independent of grazing rest (Figure 3). The correlation coefficient (r^2=0.363) is very highly significant but predictive value is low illustrating high variability ($p<0.0001$, df=52) can tell us that these two variables have somewhat of a relationship. By conventional criteria, vegetation coverage explains roughly a third of the weed coverage variation.

Figure 4 illustrates the relationship between litter depths and weed infestations at each data point throughout the Upper Big Hole riparian areas. The data is right skewed and has higher weed coverage in areas with lower litter depth, although many samples with lower litter depth also show the same amount of weed coverage as samples with higher weed coverage. Litter depth is as ambiguous a factor in driving weed coverage as the literature predicts.

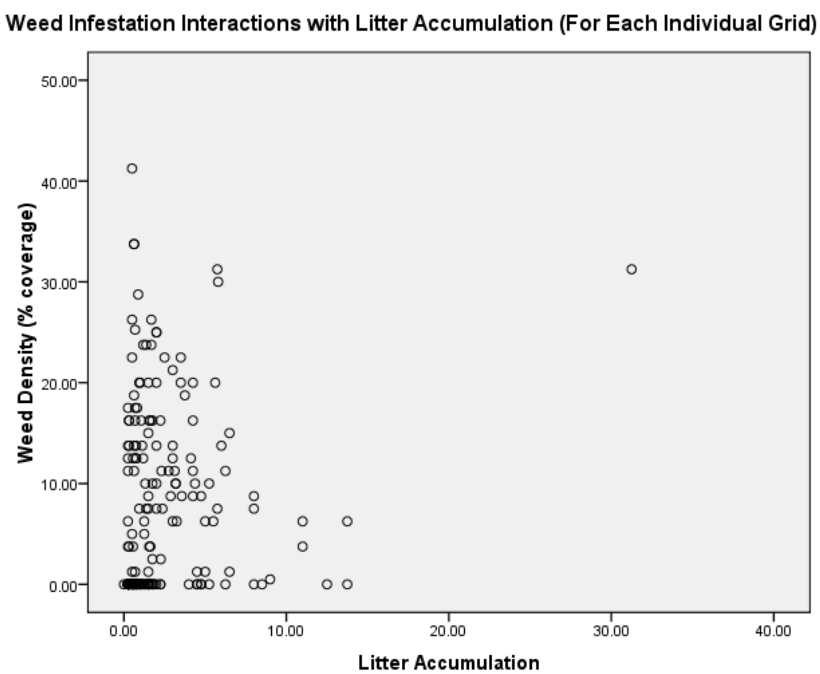

Figure 4. Weed Infestation Interactions with Litter Depth (For Each Individual Plot). Litter Depth is measured in centimeters.

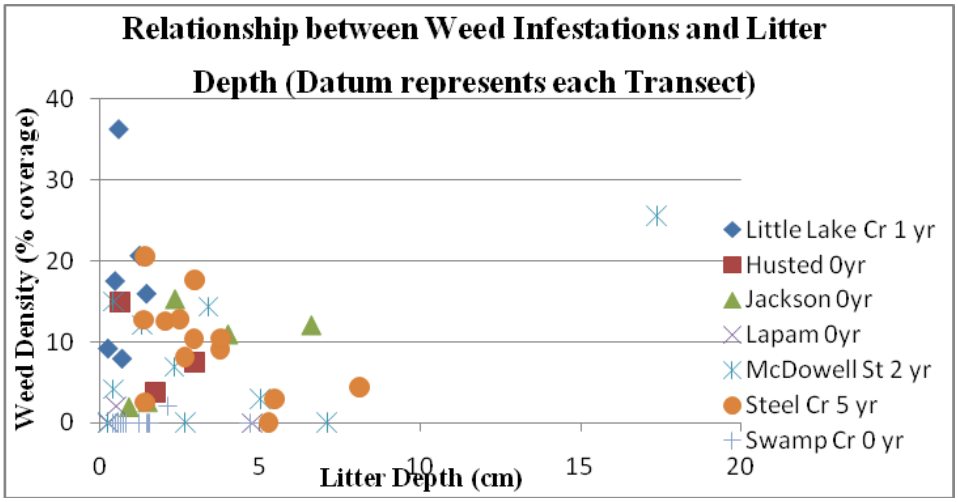

Figure 5. Relationship between weed infestations and litter depth

Figure 5 demonstrates Weed coverage as a function of litter depth at each site. We can see how the two variables interact in specific cases, but no trend or patterns present themselves.

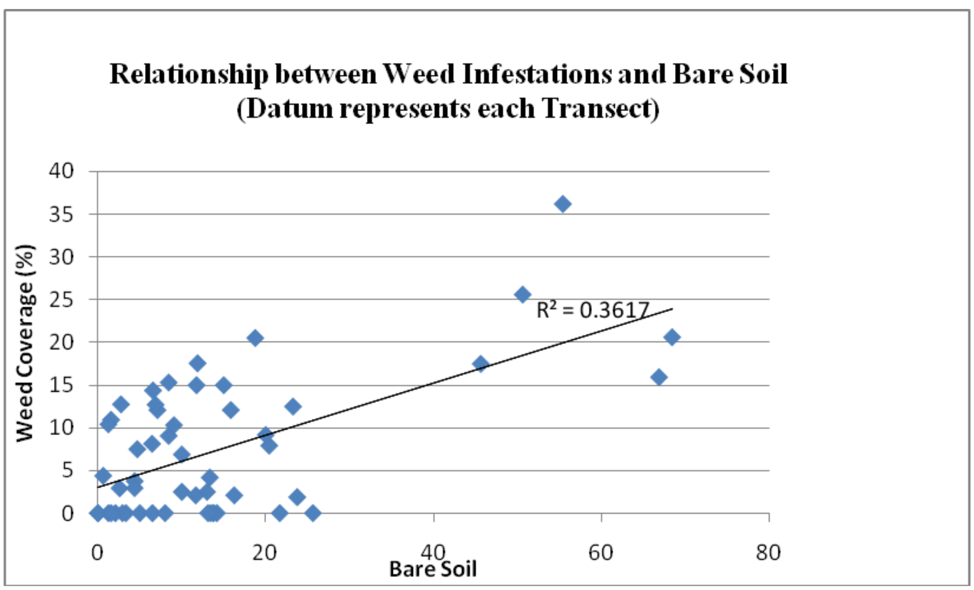

Figure 6. Relationhsip between bare soil (%) and weed cover.

Bare soil also shows the expected positive relationship (p value (two-tailed)=0.000002; df=52) with weed coverage in the riparian areas sampled (Figure 6); specifically at the Little Lake Cr. site. Thus, the bare soil variable operates in the expected way throughout the riparian sites.

Is there a significant increase in litter and bare soil at sites with longer rest periods?

Bare soil at the four sites that have not been rested is not significantly higher than the three sites that have been rested for a period of time (Figure 6). With the exception of Swamp Cr., which shows little disturbance of any kind, currently grazed sites had a higher percentage of bare soil than rested sites (including 1, 2, and 5 years). Differing grazing intensities may prevent distinguishing any differences.

Figures 4, 5 and 6 show the differences between sites for both, litter depth and bare soil. There is not a significant difference in these variables from property to property.

Is there a significant increase in noxious weed infestations with longer rest periods?

The lowest weed coverage was observed at Swamp Creek which is presently grazed and partially- fenced. This site also demonstrated highest vegetation coverage as well as low litter depth and minimal bare soil exposed. Again, this site is congruent with range literature predictions.

The Lapam property, not yet rested, had the second lowest weed coverage and also demonstrated high native vegetation coverage. This site, however, did have the largest amount of exposed bare soil and moderate litter depth.

The highest weed coverage was observed on Little Lake Cr., rested one year. This site had the lowest litter depth with moderate vegetative coverage and bare soil. Again, I attribute this to intense cattle traffic.

Steel Creek, rested for five years, had the second highest weed coverage with moderate coverage for vegetation and bare soil and highest amount of litter depth. This site exhibits possible adverse effects of a five year rest period in a riparian area; although we have no previous baseline data and cannot assume that the riparian area was "weed-free" prior to rest.

It is important to note the two highest weed coverage occur in sites with both the lowest and highest amount of litter depth. As such, there is no direct relationship between litter depth and invasive weeds during the first year measurements. We do, however see an indirect correlation with high weed coverage and bare soil and low vegetation coverage. The sites with higher vegetation and lowest amount of bare soil also have lower weeds coverage.

Figure 3 illustrates the relationship between decreased native vegetation and increased weed coverage. The right portion of the graph specifically illustrates Swamp Creek, the healthiest and most weed-free site in the monitoring project. With the exception of the Little Lake Cr. site, as native vegetative values increase, noxious weed values decrease. Again, the Little Lake Cr. site exhibits a large amount of bare soil due to cattle disturbance.

Personal Observations:

My own observations of the sites that most strongly demonstrated the complex quandary of relationships between vegetation, litter, and weed variability were at three property sites (Little Lake Creek-Hirschy, McDowell Stretch-Erb, and Swamp Creek-Erb) that are scattered throughout the valley. There were observed factors at each site that affect data variability and incorporate historical land use into variable interactions.

Little Lake Creek was the first site that I monitored. This site exhibited the lowest amount of litter depth, the most weed infestations, and the most evidence of intense cattle use of sites monitored in the Big Hole Valley. Adjacent to the fenced off riparian area was an irrigation ditch and the irrigation ditch was flanked on each side by well worn cattle paths. While I was gathering data at these sites I could clearly see that the disturbance around the irrigation ditch was spreading the infestation into the adjacent riparian area. Thus, the bare soil did not enter into the riparian zone, but the weeds propagated in the disturbed areas were encroaching into the riparian zone. While I used discretion as to the representation that these infestation may have on the data, the transects in this area often include infestations due to a narrow riparian swath which extended into the cattle path.

The McDowell Stretch exhibited highest litter and lowest coverage of native vegetation. This site has been the poster child for successful restoration within the CCAA project. This stretch has a higher percentage of cobble and other gravel substrates than any of the other sites. The McDowell stretch has had a lot of machinery present for the restoration of Rock Creek and the planting of mature willows and tublings. Wayne Elmore, a retired riparian ecologist from the BLM, and Alma Winward, retired willow ecologist with USFS, conducted a workshop on the condition of the riparian restoration efforts in the Big Hole. While several of the participants wanted to know why the machinery had been so intrusive to the soil and vegetation in this particular stretch, Mr. Elmore and Dr. Winward explained that the riverine morphology of this stretch was responsible for the “disturbed” appearance of this stretch and the amount of bare soil, river cobble, and low vegetative coverage. They further explained that the willow planting as an effort to provide shade and cool water temperatures was more efficiently done by these highly sorted gravel areas in river systems as water goes subterranean where it is cooled and then resurfaces.

Finally, Swamp Creek-Erb, is the newest property enrolled in the CCAA scheduled for riparian fencing. This site is currently still grazed and does not have a completed fence. I spotted two infestations that were unquestionably due to intense cattle traffic disturbance. These areas were small and located in the upland soil adjacent to the riparian area; there was significant soil disturbance and erosion at these sites. I did not include the transects in my analyses for two reasons: they were not representative of the effects of grazing and the infestations were not in the riparian area.

DISCUSSION

My results show no direct relationship between weed coverage and measures of grazing rest, litter depth, vegetation coverage or bare soil. However, weed coverage and vegetation coverage interact with each other in ways expected based on the range ecology literature in these sites. This suggests that the samples are representative, but that there is a complex interaction of site history, quality and current management that obscure any relationship between grazing enclosures and weed coverage. It may be in a larger set of samples across the Big Hole Valley such a relationship could be established, but none is found here.

The data collected measured four variables and how they may interact in a riparian ecosystem under grazed and un-grazed circumstances. However, the data does not include pre-existing variables such as land use history. Many of these sites have endured land management techniques that dictate their current health and function. Such land uses may include previous mitigation of noxious weed issues, grazing intensity, resting periods, and pasture utilization. We must bear in mind that the intricacies of the landowner- land relationship are beyond our knowledge; the majority of these activities span generations and leave a lasting impression on vegetative composition and function.

For the seven sites in the Upper Big Hole Valley I found no relationship between duration of grazing enclosure and weed coverage. Issues of sample size are a potential factor, however, the influence of vegetative coverage on weed coverage was strong enough to emerge from the sampling, although that relationship was observed at the transect level rather than the site level. It may be that a measure of historical grazing intensity, or the other factors, keyed to smaller areas than entire riparian ownerships might be a better measure of the influence of grazing rest on weed infestation, however, that cannot be established from this single season sample.

Whether bare soil is greater in rested versus non-rested areas is not discernable from this data. A large amount of variability exists between sites. There are no significant patterns, trends, or relationships. A larger number of sample sites could help minimize this variability. Again, the more prominent factor is land management regimes that existed before the rest was prescribed.

Similar to conventional knowledge in the literature, relationships between litter depth and noxious weeds are incredibly variable. The data collected shows the greatest amount of variability between these two variables. The limited sampled sites span over twenty five miles and exhibit drastically different soils, vegetation, and land uses. Researching litter depth effects on noxious weeds is a difficult task; this data did not demonstrate any trends or established relationship.

The riparian weed monitoring project was one of many components of an overarching restoration scheme, developed to encourage collaboration conservation throughout an entire watershed. While the threat of Canada thistle is real in the Big Hole Valley, the progression of amiable relationships between private landowners and government land managers is noticeable. While livestock enclosures are effective for willow regeneration, stream bank stability and overall critical habitat for the fluvial Arctic grayling they may preclude grazing of the Canada thistle and thus exacerbate the proliferation of this weed. However, the potential threat that Canada thistle poses to a riparian ecosystem compared to other potential management impacts is disputable.

BASELINE FOR HERBICIDAL TREATMENT EVALUATION

Part of the monitoring effort was to set a baseline for evaluating the effectiveness of herbicide treatments in combating weed infestation. Thus, the procedure and data for the first year baseline are reported here to support later analysis when data collection is completed. Pintlar Weed Management Services completed a weed survey and treatment project on three enclosures (Steel Creek, McDowell, and Little Lake Creek) during the summer and early fall of 2008 (Tillman, 2008). Tillman described that “Canada thistle was spread throughout the whole project area under and in the willows as well as out in the open areas of the enclosures…..the majority of the areas along the outside of the enclosures that had been grazed were devoid of Canada thistle.” Tillman made comments regarding other variables in his project report, “Several areas in the Little Lake Creek enclosure availed themselves to broadcast spraying due to the weed coverage and lack of other vegetation other than native grasses.”

Ray Tillman also provided photos (Figures 8 and 9 in Appendix B) illustrating his observations of weed infestations inside versus outside the fencing enclosures; these photos are included in the appendices. The effectiveness of herbicidal treatment at the three listed sites will be monitored in subsequent years.

OVERALL SAMPLING ISSUES

One of the main obstacles was developing an effective monitoring program under tight time constraints that was affordable and could be executed by future interns with varied experience and knowledge.

Timeliness was another issue regarding this project. My plan to graduate in May 2009 only allowed one complete field season to collect data before writing this report. Interest in further data collection and analysis has been expressed by private and government organizations, though it will not be included in my professional paper. Given only one year of field data, I can only perform preliminary data analysis.

Selecting sites that shared similar attributes but were at different periods in their rest was difficult. The CCAA program has 36 enrolled landowners; however only 24 of them have actually erected fences. The majority of enrolled landowners have only recently signed the CCAA; therefore there are many property sites that have little to no rest.

For the duration of my monitoring, I had three sites that were immediately adjacent to each other. After consultation with several government agency employees, I knew that one site was the reference stretch for all restoration projects in the Big Hole Valley (Husted property); I was also under the impression that one site (either Jackson or Lapam) was rested for 0 years and the other was rested for 3 years. However, towards the end of the project I found out that both had only been rested for 0 years. Three sites without rest has altered my project design and thus the representation of different succession rest periods was not what was originally intended. Ultimately, there was a miscommunication about these project sites in question due to the high amount of land management professionals working on different aspects of this restoration project.

While collecting data I observed that each site, while adjacent to each other, has very different characteristics as a result of prior land uses or management regimes. Every landowner prescribes their own grazing regimen and land uses. Also, because the valley is flood irrigated there are myriad irrigation canals spurring off of the main channel of the Big Hole River. These irrigation canals require maintenance and provide main corridors for wildlife and domestic animals. Overall, these irrigation canals are numerous across the landscape and can also create a significant amount of soil disturbance. These spurs can be large contributors to any weedy infestations besides grazing regimes.

Most importantly, ecological relationships in riparian areas are defined by many more variables than this project is able to address; however we cannot negate them. Land uses span centuries and leave their imprint indefinitely. Each site that I monitored has endured a specific land use, both similar and different, to the other sites that were monitored. This must be established and recognized while analyzing the data; declaring trends without knowing the intimate history of the specific land is a great caution of mine.

I have gained valuable knowledge in experimental design, implementation, and data analysis. I understand the downfalls of my project design and have learned many lessons to reinforce the experiment throughout the design and sampling process. Overall, the communication between ranchers and government agencies was one of the most difficult tasks regarding the number of people involved, the myriad restorative projects occurring throughout the valley, and the varied objectives from each stakeholder.

Figures and Tables

APPENDIX A

Swamp Creek Stretch:
Owners: Cal Erb.
Period of time rested: Most of this site has not been rested at all thus far.
Number of Transects: **12**
The riparian fences have not been completed.

Lapam: 100
Owners: Max and Debbie Lapam
Period of time rested: **0**
Number of transects: 3
The fence for this area was completed in fall 2008.

Jackson: 100 acres
Owner: John Jackson
Period of time rested: 0
Number of Transects: 4
The fence for this area was completed in fall 2008.

Husted: 490 acres
Owner: Vince Husted
Period of time rested: none.
Number of transects: 3
This site is used as a "reference" for the CCAA program. The willow community and other riparian ecosystem components have been mostly unaltered and demonstrate historical, natural conditions of the Big Hole River. Grazing is not excluded from the riparian area but naturally minimized because the willows community forms a natural barrier. This is a good site to obtain some baseline data. It is also located adjacent to the Jackson and Lapam sites.

McDowell Stretch: 1045 acres
Owner: Cal Erb
Period of time rested: 2 years.
Number of Transects: 10
This site has had active restoration projects completed on the lower stretch and to one of the main tributaries, Rock Creek. The restoration has involved riparian sloping, reopening of historic navigation channels, and large caliber Willow transplanting.

Little Lake Creek Rd. Site: 168 acres
Owner: Heidi Hirschy
Period of time rested: 1 year.
Number of Transects: 6
This stretch has also undergone intensive restoration with bank reshaping, large caliber willow transplants, and willow plugging. There is a very serious Canada Thistle problem here, although many of the infestations occur in areas where there has been serious

disturbance or along the irrigation channel to the east of the Big Hole River. The weed infestations are also more prominent in depressions formed from cattle water crossings. This site was sprayed with herbicide in fall 2008.

Steel Creek Site: 79 acres
Owner: Fred Hirschy
Period of time rested: 5 years. Grazed Spring '08.
Number of Transects: 13
This site was grazed spring 2008 after five years of rest; however there are two acres at the top of the site that were not and will not be grazed. The two acres fall on both sides of Steel Creek, one side of the creek can be a herbicide control. We are using both sides as our control for non-grazing.
The Canada Thistle is thickest in this site more than any other site. This site was sprayed with herbicide in fall 2008.

APPENDIX B

Figure 8. Canada thistle infestations inside versus outside enclosure. (Tillman, 2008)

Figure 9. Canada thistle infestations inside versus outside enclosure. (Tillman, 2008)

APPENDIX C

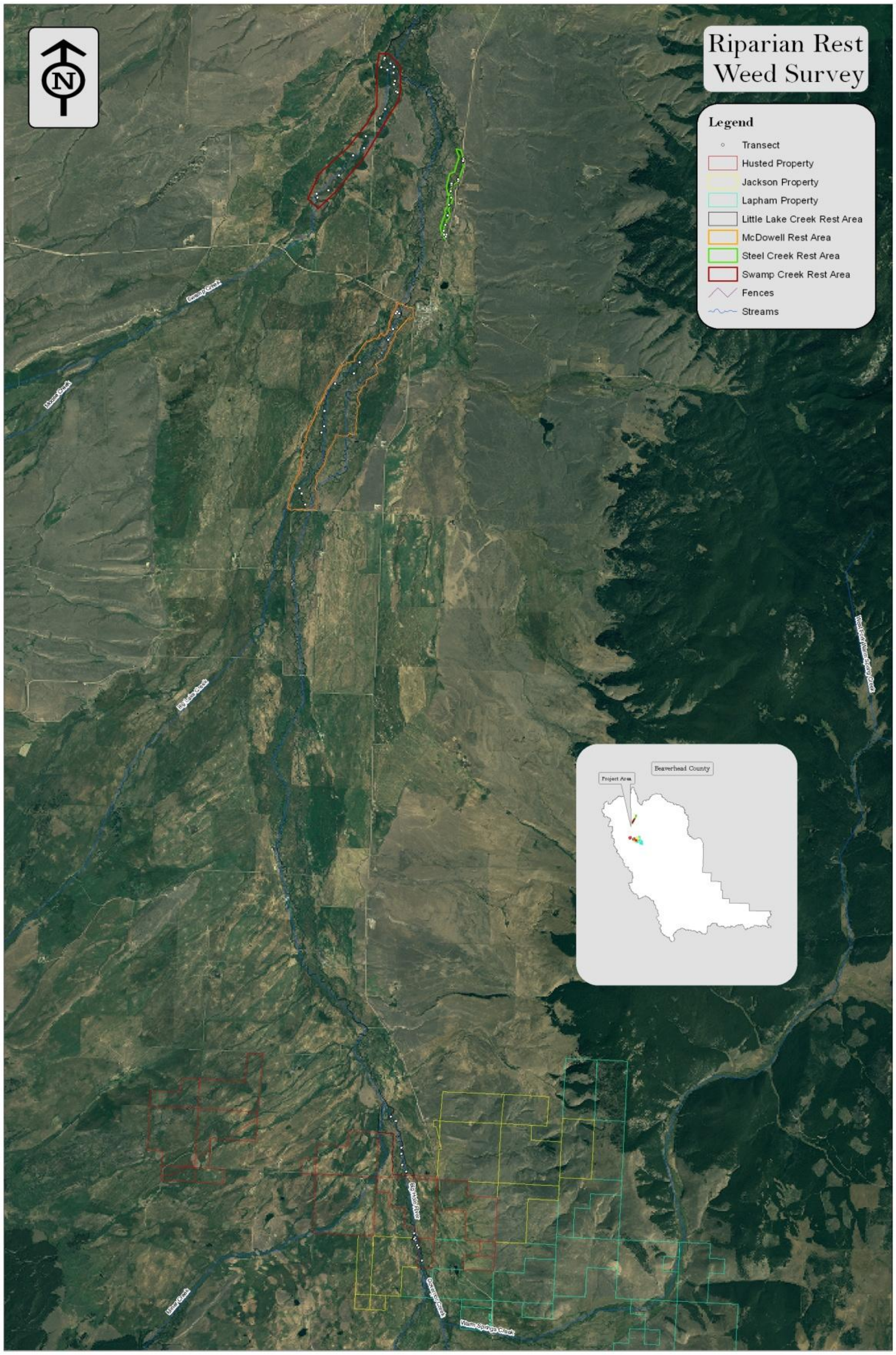

Figure 10. Big Hole Valley map with all monitoring points.

APPENDIX D

Works Cited

Amor, R. L., and R. C. Harris. "Control of Cirsium arvense (L.) Scop. by herbicidesand mowing." Weed Research 17 (1977): 303-09.

Anderson, Lee. "Keeping thistles at bay." ACRES USA (2001): 26.

Belsky, A. J. "Does herbivory benefit plants? A review of the evidence." American Naturalist 127 (1986): 870-92.

Canada. Dept. of Agricultural, Food, and Nutritional Science. ALBERTA AGRICULTURAL RESEARCH INSTITUTE. Management of Canada Thistle in Pasture. By E. W. Bork, C. W. Grekul, and S. L. DeBruijn. Edmonton: University of Alberta, 2005.

Carson, W. P., and C. J. Peterson. "The role of litter in an old-field community: Impact of litter quantity in different seasons on plant species richness and abundance." Oecologia (Berlin) 85 (1990): 8-13.

Chambers, J. C., and J. M. MacMahon. "Annual Review of Ecology and Systematic." Review. A day in the life of a seed: Movements and fates of seeds and their implications for natural and managed systems (1994): 263-92.

Corbin, Jeffrey D., and Carla M. D'Antonio. "Comptetion Between Native Perrencial Grasses Exotic Annual Grasses: Impolications For An HistoricalInvasion." Ecology 85 (2004): 1273-283.

DeJong, T. J., and P.G. L. Klinkhamer. "The negative effect of litter of parent plants of Cirsium vulgare to their offspring." Oecologia 65 (1985): 153-66.

De Bruijn, S.L. . Biological control of Canada thistle in temperate pastures using high coverage rotational cattle grazing. Biological Control 36 (2006):305-315.

Donald, W. W. "Management and control of Canada thistle." Review of Weed Science 5 (1990): 193-250.

"Endangered Species Act." Endangered Species Act. Red Lodge Clearinghouse. 27 Apr. 2008 <www.rlch.org>.

Evans, R. A., and J. Young. "Plant litter and establishment of alien annual weed species in rangeland communities." Weed Science 18 (1970): 697-703.

Facelli, J. M. "Response to grazing after nine years of cattle exclusion in a Flooding Pampa grassland." Vegetation 78 (1988): 21-25.

Facelli, Jose M., and Steward T. Pickett. "Plant Litter: Its Dynamics and Effects on Plant Community Structure." Botanical Review 57 (1991): 1-32.

Fluvial Arctic Grayling. US FWS. 27 Apr. 2008 <www.fws.gov>.

Fowler, N. L. "Microsite requirements for germination and establishment of three grasses species." American Midlander Naturalist 115 (1986): 131-45.

Green, J. D., and J. R. Martin. Weed Management in Grass Pastures, Hayfields, and Fencerows. Lexington: Cooperative Extension Service-University of Kentucky, 1998.

Grekul, Chad W., Dan E. Cole, and Edward W. Bork. "Canada Thistle (Cirsium arvense) and Pasture Forage Responses to Wiping with." Weed Technology 19 (2005): 298-306.

Grime, J. P. Plant strategies and vegetation processe. New York: John Wiley & Son, 1979.

Guretzky, John A., Kenneth J. Moore, Charles E. Brummer, and Lee C. Burras. "Species Diversity and Functional Composition of Pastures that Vary in." Crop Science Society of America 45 (2005): 282-89.

Hamrick, J. L., and J. M. Lee. "Effects of soil surface topography and litter cover on germination, survival and growth of musk thistle." American Journal of Botany 74 (1987): 451-57.

Hanson, Brad. "Canada Thistle." College of Natural Resources. University of Idaho. 11 Mar. 2009 <www.uidaho.edu>.

Kauffman, J. B., W. C. Krueger, and M. Vavra. "Effects of late season cattle grazing on riparian plant communities." Journal of Range Management 36 (1984): 685-91.

Kemmis, Daniel. This Sovereign Land A New Vision For Governing The West. New York: Island P, 2001.

Knapp, A. K., and T. R. Seastedt. "Detritus depth limits productivity of tallgrass prairie." BioScience 36 (1986): 622-68.

Lamothe, Pete, Emma Rens, Jeff Everett, Jim Magee, and Mike Roberts. "Progress of the CCAA." BigHole Watershed Committee Meeting. Community Hall, Divide. 16 Apr. 2008.

"Montana Fluvial Arctic Grayling." SAVING THE MONTANA FLUVIAL ARCTIC GRAYLING. Center for Biological Diversity. Jan. 2009 <www.biologicaldiversity.org>.

Nie, Martin. "Wildlife and Biodiversity: Endangered Species Act." Natural Resource Law and Policy. University of Montana, Missoula. 10 Apr. 2008.

Penfound, W. T. "Effect of denudation on the productivity of grassland." Ecology 45 (1964): 838-45.

Rasband, J. J., S. James, and S. Marks. Natural Resource Law and Policy. New York: Foundation P, 2004.

Rice, E. L., and R. L. Parenti. "Causes of decreases in productivity in undisturbed tallgrass prairie." American Journal of Botany 65 (1978): 1091-097.

Ringold, Paul L., Teresa K. Magee, and David V. Peck. "Twelve invasive plant taxa in US western riparian ecosystems." The North American Benthological Society 27 (2008): 949-66.

Rotundo, Jose L., and Martin R. Aguiar. "Litter effects on plant regeneration in arid lands: a complex." Journal of Ecology 93 (2005): 829-38.

Russell, Sharman Apt. Kill the Cowboy A Battle of Mythology in the New West. New York: Bison Books, 2001.

Savory, Allan, and Jody Butterfield. Holistic Management A New Framework for Decision Making. New York: Island P, 1998.

Stachon, W. J., and R. L. Zimdahl. "Allelopathic Activity of Canada Thistle (*Cirsium arvense*) in Colorado." Weed Science Society of America 28 (1980): 83-86.

Sullivan, Preston G. Thistle Control Alternatives. Aug. 2004. National Sustainable Agriculture Information Service. <www.attra.ncat.org>.

Tillman, Ray. Upper Big Hole Weed Report 2008. Rep. Wise River, MT: Pintler Weed Management, 2008.

USA. Department of Agriculture. The nature, ecology, and control of Canada thistle. By J. M. Hodgson. Vol. 1386. Washington D.C.: USDA, 1968.

USA. Department of Agriculture. US Forest Service. Rangeland Riparian Systems. By Wayne Elmore. USFS, 1989.

USA. Department of Interior. Fish and Wildlife Service. U.S. Fish and Wildlife Service, Mountain-Prairie Region. Denver: Mountain-Prairie Fisheries, 2008.

USA. Natural Resource Conservation Service. Bozeman, MT. Ecology and Management of Canada thistle [*Cirsium arvense* (L.) Scop.]. By Jim Jacobs, Joanna Sciegienka,, and Fabian Menalled. Vol. Invasive Species Technical Note No. MT-5. Bozeman: Montana State University, 2006.

USA. North Dakato State University. Extension Office. Perennial and Biennial Thistle Control. By Rodney G. Lym and Richard Zollinger. Fargo: NDSU, 2000.

USA. US Department of Agriculture. Penn State College of Agricultural Sciences. Weed Management in Pasture Systems. University Park: Pennsylvania, 2001.

Van Woudenberg, Astrid M. "Grazing Impacts on the Biodiversity of Riparian Ecosystems." Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk, Kamloops, B.C. Biology and Management of Species and Habitats at Risk, University College of Carlboo, Kamloops. Vol. 2. 1999. 15-19.

Wilson, R. G., and S. D. Kachman. "Effect of perennial grasses on Canada thistle." Weed Technol 13 (1999): 83-87.